# Employing support vector machine, statistical and geostatistical methods to design the detailed exploration grid of Khomein-Robat Pb-Zn deposit

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**Keywords**: Khomein-Robat Pb-Zn deposit, Support Vector Machine (SVM), Designing exploration grid, Statistical method, Geostatistical method

## 1-Introduction

One of the essential requirements in the all stages of an exploration operation for deposits is the precise locating the exploration works or design of the exploration grid. In general, the arrangement of exploration works is called the exploration grid. The exploration grid has the variety of types that the type, shape and dimensions of the grid depend on the geological conditions and characteristics of the deposit (Ahmadi, 2005). Today, issues related to mineral exploration and design of exploration grids require the extensive use of all sciences, especially new sciences, fast, accurate and intelligent techniques (Smirnoff et al., 2008). In the present research, designing exploration grid has been carried out for Khomein-Robat Pb-Zn deposit as a worthwhile small-scale metallic deposit. The Robat Pb-Zn deposit is located in 32 km west of Khomein city, 10 km northwest of Ghourchi Bashi town and 2 km south of Robat-e-Paeen village. The studied region comprises three mineralized areas called Arregijeh, Takhte-Hossein and Baraftab where Takhte-Hossein and Baraftab are adjacent to each other. From structurally view point, the study area is located in the Sanandaj-Sirjan metamorphic zone and consists of Cretaceous carbonate-clastic cover over the old metamorphic complex. This region, in terms of mineralization, especially the presence of Pb-Zn minerals, is a part of the Malayer-Isfahan mineralization strip (Pichab kansar, 2009). According to the geological conditions of the deposit, the type and amount of available exploratory information (assay data of trenches, test pits, outcrops, semi-deep and deep boreholes) statistical and geostatistical methods have been used to design systematic exploration grid for Arregijeh region.

## 2-Methodology

In this research, primary classification of Khomein-Robat-Arregijeh Pb-Zn deposit has been carried out first, using support vector machine (SVM) method. SVMs are part of supervised training methods used to solve classification, regression and ranking problems (Ivanciuc, 2007; Cortes and Vapnik, 1995). The classification model of SVM is used to solve the data classification problems and the regression type model is applied to solve the prediction problems. Two sets of variables are needed to perform a supervised classification; one set is target variable that defines the target classes and the other ones are predictor variables which using them, model obtained from multivariate analyzes, predicts the membership of data into one of the defined classes. The radial basis kernel function was used to generate the SVM model because favorite results have been obtained for nonlinear classification in the employed researches by this kind of kernel function. Optimal values for parameters of kernel function were also obtained by searching in a gridded space. To achieve the goal, 548 available multivariate data point comprising 337 induced polarization (IP) and resistivity (Rs) geophysical data, 211 rock type and Pb-Zn assay data from outcrops, trenches and test pits were used. Three variables IP, Rs and rock type were considered as predictive variables as well as Pb-Zn assay as target variable. Afterward through designing and training an SVM model, on the basis of three cut off grade 1.5, 2 and 3 percent, the deposit was classified to two classes: high-grade zone or anomaly (above the cut off grade) and low-grade zone or

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DOI: 10.22055/AAG.2019.29369.1977
Received 2019-05-03
Accepted 2019-10-12

background (lower than cut off grade). Afterward exploratory boreholes scattered in the region, were drilled in the locations known as high-grade zone as well as anomalies of the geophysical pseudo-sections. In the next, using all exploration information, designing the detailed exploration grid of the deposit was performed through both statistical and geostatistical methods. The classical statistics method is used to obtain an overall idea and design the initial survey grid. For this purpose, data of 282 samples from 37 trenches, 58 hand-held surface samples from mineralization outcrops and 2 samples from 2 test pits as surface explorations and assay data of 144 cores from 43 boreholes as semi-deep and deep exploration works were used. For variography of the study area and then design an optimal exploration grid, SGeMS geostatistical software was employed. Since surface and deep exploration works are not significantly correlated, therefore 3-D variography was only performed for borehole data

## 3- Results and discussion

Evaluation of SVM model performance by various error measurement criteria such as R2, MSE and RMSE showed that the applied method at this stage of surface exploration operation in the region has yielded acceptable results. A rectangular grid with dimensions of 36*35m was obtained by analytical method based on classical statistics. Employing geostatistical method and 3-D variography for Pb-Zn assays of the boreholes using SGeMS software concluded a square grid with dimensions of 55*55m. Comparing the features of the exploration grids designed by both statistical and geostatistical methods show that in terms of grid geometry, both grids are approximately square; in other words the studied deposit is not specific spatial orientated.

## 4-Conclusions

According to the previous studies and results of the present research, to continue studies semi-deep exploration activities (i.e. drill holes) are suggested at the nodes of the new systematic exploration grid, designed by geostatistical method due to more accuracy of the method. Since, based on the evidences and data from scattered-deep boreholes, the burial depth of the ore is not very high, therefore, semi-deep exploration is suggested for the detailed stage exploration. At the end the results of the proposed systematic exploration grid must be studied comprehensively, because the results of detailed exploration will be very useful to estimate the ore deposit reserve with high accuracy.

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